**MRI OF THE SHOULDER**

*The basics*

William B. Marmorlin, M.D.
Professor of Radiology
Director, Division of Musculoskeletal Imaging
Thomas Jefferson University Hospital, Philadelphia, PA

---

**Shoulder-Axial Imaging Plane**

Relevant Anatomy

Axial Imaging Plane
Prescribe plane parallel to humeral shaft. Cover from AC joint through proximal humeral diaphysis.

---

**Shoulder – Axial Imaging Plane**

*Have patient bend arm at elbow to 90 degrees. Rotate laterally to externally rotate shoulder to assure subscapularis tendon is NOT bunched. Note location of bicipital grooves in internal and external rotation.*

---

**Shoulder-Oblique Coronal Imaging Plane**

Relevant Anatomy

Coronal Imaging Plane
Prescribe coronal plane parallel to supraspinatus muscle.

---

**Shoulder-Oblique Sagittal Imaging Plane**

Relevant Anatomy

Sagittal Imaging Plane
Prescribe sagittal plane for the images with line parallel to bony glenoid. Image from scapular wing through deltoid muscle.

---

**Signal Dropoff (Shading)**

- Coil malpositioning
- Incorrect coil
- Check scout to verify problem
IMPINGEMENT

Causes of Impingement

‘Primary’ - narrow rotator cuff interval

• Subacromial spur
• Anterior hooked acromion
• Os acromiale - “hinge”
• Downsloping acromion
• AC OA - inferior spurs

Hodge, Beaulieu CF, et al. JMRI 2001; 13:748

Causes of Impingement

‘Secondary’ – instability leading to impingement

• Labral tear
• Glenohumeral cartilage loss
• Glenoid dysplasia
• Multidirectional Instability


Acromioclavicular Osteoarthritis:

Causes of Impingement

Acromioclavicular Osteoarthritis

Subacromial Spur
Subacromial Spur at Surgery

Hooked Acromion

Acromial morphology
- 1) Flat
- 2) Curved
- 3) Hooked anteriorly
- 4) Reverse curve
Hooking associated with impingement

Causes of Impingement

“Acromial Morphology”
• Morrison & Bigliani, Orthoped. Trans, 1986;10:228 correlated shape of acromion as seen on supraspinatus outlet radiographs with occurrence of RC pathology
• Poor interobserver consistancy
• Descriptive morphology may be more important

Hooked Acromion: just a subacromial spur?

Causes of Impingement

Downsloping Acromion
• Lateral Downsloping:
  – Impingement at ‘outlet’ of subacromial space
  – Associated with lateral subacromial spur
Causes of Impingement

**Os Acromiale:**
- Acromial Ossification Centers
  - Pre-Acromion (CA ligament)
  - Meta-Acromion
  - Four separate ossification centers
  - One of the last ossification centers to fuse
  - Don’t call before age 21!

Lack of fusion = **os acromiale**

Acromial Ossification Centers

- Pre-Acromion (CA ligament)
- Meta-Acromion
- Meso-Acromion

Unossified area = os acromiale

**Os Acromiale**

- "DOUBLE AC JOINT"
- Fluid, edema, cysts at interval
- Os acts as a hinge
- Deltoid pulls os into cuff tendons

**PSEUDARTHROSIS OF OS**

- Synchondrosis
- Pseudarthrosis
- DJD & effusion

Subacromial / Subdeltoid Bursitis

- Bursitis, spur, but cuff intact

Rotator Cuff Degeneration

- "Tendinosis"
- ‘Mucoid degeneration’
Calcific Tendinosis / Bursitis

- Hydroxyapatite deposition (HADD) in tendon
- Mimics RTC tear on physical exam
- Explodes through tendon into bursa
- Toothpaste consistency
- Sometimes asymptomatic
- Large deposit - can block abduction
- Supraspinatus > infraspinatus > subscapularis

Terminology:
- Document tendon involved, size of tear
- "Complete tear" (whole tendon) – careful!
- Full thickness tear
  - From bursal to articular surface – can be small
- Partial thickness tear
  - Bursal surface
  - Under surface

Rotator Cuff Tear

Supraspinatus – Anterior leading edge

SAGITTAL OBLIQUE PD FSE FS  AXIAL PD FSE FS

Supraspinatus – Anterior leading edge

CORONAL OBLIQUE PD FSE FS  CORONAL OBLIQUE T2 FSE FS
Undersurface at distal, anterior insertion ("rim rent")

Partial thickness tears:

Interstitial ("hidden") tear

Bursal surface partial thickness tear

Massive SS/IS tear with retraction in pro football player

Supraspinatus – full thickness (measure!)

CORONAL OBLIQUE STIR

AXIAL PD FSE FS

Supraspinatus – Delaminating Tear

Intratendinous propagation
Supraspinatus – Delaminating Tear

Intratendinous propagation without full thickness component

Infraspinatus

Rotator Cuff Tear

Intramuscular cyst with partial thickness tear

Contrast in SA/SD bursa from joint injection

Full Thickness Supraspinatus Tear on Direct MR Arthrogram

CORONAL OBLIQUE T1 SE Fatsat MRAr

Rotator Cuff Tear

Poor prognostic factors for successful surgical repair

Describe on report:
- Tendon retraction > 3 cm.
- Large tear (multiple tendons)
- Muscle atrophy

“Rotator Cuff Arthropathy”
Rotator Cuff Muscle Edema / Atrophy

Massive Rotator Cuff Tear
with Subscapularis Tear, retraction

Glenohumeral Stabilization

- Primary glenohumeral stabilizers
  - Glenoid cup
  - Intact cartilage, glenoid labrum - “suction effect”
  - Capsule / glenohumeral ligaments (esp. inferior G-H ligament)

- Secondary stabilizers (“dynamic stabilizers”)
  - Rotator cuff (4 muscles in concert pull humeral head into glenoid)
  - Long head biceps (humeral head depressor)
  - Deltoid, scapular muscles

The Shoulder – Predisposed to Instability

Rotator Cuff as a Dynamic Stabilizer
At rest, cuff provides passive stabilization

Wide range of motion—...at the expense of stability
As arm abducts, cuff muscles pull humeral head into glenoid; assist arm elevation.

Instability Associated with Impingement

- Instability may lead to impingement
  - hypermobility of glenohumeral joint allows superior migration humeral head during deltoid activity
- Impingement may lead to instability
  - rotator cuff tear / dysfunction causes muscle imbalance, subluxation

Rules of Thumb - MR Diagnosis of Labral Tears

- Pitfalls
  - Wide variation in normal labral morphology
    - sharp, blunted, round, cleaved, absent
  - Glenoid articular cartilage under labrum
    - can look like tear, but not fluid signal

Rules of Thumb - MR Diagnosis of Labral Tears

- Pitfalls
  - Buford complex
    - thick middle glenohumeral ligament with small/absent anterosuperior labrum
  - Sublabral foramen
    - Anterosuperior ‘hole’ in labrum
  - Recess
    - Superior labrum

Rules of Thumb - MR Diagnosis of Labral Tears

- For this purpose let’s divide the labrum into 3 areas:
  - Superior
  - Anterosuperior
  - All other areas (posterior, inferior, anteroinferior)

Imagine that the Glenoid is a Clockface

12 O’clock: Biceps origin
3 O’clock: Anterior
Imagine that the Glenoid is a Clockface

Superior Labral Region
11 o’clock to 1 o’clock

• Fluid under labrum: can be normal
  – Sublabral recess
  • fluid pointing to head (hugging glenoid): normal recess
  – Tear
  • fluid pointing to shoulder (entering labrum) = tear

Anterosuperior Labral Region
1 o’clock to 3 o’clock

• Fluid under / through labrum: can be normal
  – Sublabral foramen
  • Isolated tear of the anterosuperior labrum: VERY rare
  • if it doesn’t extend to superior or anteroinferior labrum= normal variation

Rules of Thumb - MR Diagnosis of Labral Tears

• Posterior labrum, inferior, anteroinferior labrum: "tight attachments"
  – fluid in or underneath = tear or detachment
• Superior labrum, anterosuperior labrum: "loose attachments"
  – fluid underneath may be normal

Sublabral Foramen
How to Differentiate from Tear

Variation occurs from 1:00 to 3:00 on glenoid -by 3:30 position, should be back to normal appearance

Buford Complex

DEFINITION
1) Diminutive OR absent anterosuperior labrum *AND*
2) Thick, bandlike middle glenohumeral ligament (MGHL)

KEY: Glenohumeral ligaments are reflections of the capsule… they will go back to the capsule if followed from origin to insertion!

• Posterior labrum, inferior, anteroinferior labrum: "tight attachments"
  – fluid in or underneath = tear or detachment
• Superior labrum, anterosuperior labrum: "loose attachments"
  – fluid underneath may be normal
**Buford Complex**

*How to Differentiate from Tear*

Follow inferiorly: if it goes to:
- capsule → MGHL
- glenoid → labral tear

**KEY:** GHLs are reflections of the capsule

---

**Displaced Bankart Lesion vs. Buford**

Labrum (detached) MGHL

---

**Rule of Thumb: Glenoid Shape**

The Herculoids

“Gloop”

L’il Abner

“Schmoo”

**Anterosuperior Labrum**

- *Labral variation* (Buford, sublabral foramen) correlates with underlying osseous variation
- Look at shape of the glenoid on sagittal images
  - Oval
  - Pear-shaped ("dipped")
- If there is a ‘dip’ in the bone anterosuperiorly, more likely to be a variation in overlying soft tissues

---

**Glenoid Morphology and Labral Variation**

<table>
<thead>
<tr>
<th>Glenoid Morphology</th>
<th>Buford</th>
<th>Sublabral Foramen</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVOID</td>
<td>75/88  (85%)</td>
<td>11%</td>
</tr>
<tr>
<td>NOTCHED</td>
<td>13/88  (15%)</td>
<td>96%</td>
</tr>
</tbody>
</table>

- Normal
- Diminutive
- Buford
- Sublabral Foramen

---

**OVOID**

- Notched 15%
- 85% Ovoid

---

**NOTCHED**

- Buford 31%
- Sublabral Foramen 15%
- Normal 31%
Normal Labrum

MGHL

Ovoid

Labrum

Diminutive Labrum

“Notched” Glenoid

MGHL

Paralabral Cysts

Rule of Thumb

Paralabral Cysts – are your friends!

Nearly always associated with labral tear; thereby correlate with instability

- Can impinge on adjacent nerves early - muscle edema
  late - fatty atrophy
- Can erode into glenoid

Sublabral Foramen

MGHL

Labrum

Notched

Buford Complex

MGHL

Notched

Suprascapular notch

Spinoglenoid notch

Paralabral Cysts

4/3/2017
Paralabral Cysts

- Muscle atrophy
- Infraspinatus edema - early atrophy
- Paralabral cyst in spinoglenoid notch
- Glenoid erosion "intraosseous ganglion"

Posterior Instability

- Posterior labral tear / paralabral cyst
- Cyst
- Labral tear
- Secondary OA

Rules of Thumb - MR Diagnosis of Labral Tears

- Inferior Labral Tear
  - Double axillary recess

Inferior Paralabral Cyst

- Can impinge on axillary nerve in quadrilateral space "quadrilateral space syndrome"
- Supplies teres minor, posterior deltoid

Labral / Capsular Lesions

Three ‘Zones’

- Bankart
- Perthes
- ALPSA
- GLAD
- HAGLs
- SLAP - superior at biceps origin
- Posterior labral tear

Anteroinferior Labral-capsular Pathology

Anterior Dislocation

- Hill-Sachs defect: posterior-lateral-superior humeral head
- Bankart fracture: antero-inferior glenoid rim
- Created by impaction during dislocation
Anteroinferior Labral-capsular Pathology

Anterior Dislocation

- Bankart fracture
- Hill-Sachs defect

Hill-Sachs Defect

- Diagnosis:
  - Axial images
  - Upper 2-3 images (humeral head should be round)
  - Flattening or dent posterolaterally
  - Hill-Sachs
  - False positive: normal sulcus created by greater tuberosity
    - "above coracoid" criterion - limited by technologist plane selection

Anterior Dislocation: Hill-Sachs Defect and Bankart Fracture

Bankart Fracture

- Greater tuberosity avulsion / HAGL

Anterior Dislocation: >35 years old, greater tuberosity avulsion common

Double Axillary Recess

- CASE 1
  - Recent dislocation
  - Bone bruise at greater tuberosity
  - Anteroinferior labral tear

- CASE 2
  - Inferior labral detachment
Bankart Lesion
Anteroinferior Labral Tear

Perthes Lesion
nondisplaced Bankart

Synovialization over Perthes Lesion
Can simulate intact labrum

ALPSA
Anterior Labral Periosteal Sleeve
Avulsion

Labral Tear + Cartilage Defect
DDx
-Dislocation
-Secondary OA
-GLAD
GLAD: Glenoid Labrum Articular Defect
(aanteroinferior labral tear + cartilage defect)

Acute injury – direct impaction in a professional football player

HAGL
Humeral Avulsion of the Glenohumeral Ligament

Capsular tear does not have to be at the humerus to be called a HAGL
Fluid / contrast should not leak from joint into axilla

HAGL Lesion
“J” Sign

Also greater tuberosity avulsion
Recent dislocation

HAGL on ABER

Clinical importance:
Requires open surgical approach

Image courtesy of Dr. Ochoa, Pittsburgh, PA

Posterior HAGL (PHAGL)

PHAGL
Labral / Capsular Lesions
- Bankart
- Perthes
- ALPSA
- GLAD
- HAGL
- SLAP - superior at biceps origin
- Posterior labral tear

Normal Labral Variation
Posterior
- Flat
- Round
- Blunted

Posterior Labral Tear
Any fluid or contrast in or around posterior labrum = tear

Posterior Labral Tear
Posterior Dislocation
- Anterior trough
- Posterior labral Tear / capsular stripping

Posterior Labral Tear
Chronic Unidirectional Posterior Instability
Subluxation

Posterior Instability
Posterior glenoid erosion
Labral / Capsular Lesions
- Bankart
- Perthes
- ALPSA
- GLAD
- HAGL

- SLAP - superior at biceps origin
- Posterior labral tear

SLAP Lesion
Superior Labrum Anterior to Posterior tear

- Secondary to avulsive stress from origin of long head of the biceps tendon
- Pain, less likely to have clinical instability than patients with anterior/inferior labral tear

Superior Labrum - Variation
- Kreitner KF, AJR 1998; 170:599
  - 17 cadaveric shoulders
  - Superior labrum: sublabral recess in 71%
  - Recess covered with synovial lining
  - Better depicted on MRA than non-contrast MRI

SLAP
Superior Labral tear Anterior to Posterior

Fluid, contrast should not enter substance of superior labrum

SLAP
Tear may extend down biceps
**SLAP - TYPES**

I  Undersurface fraying
II  Superior labral tear
III Bucket-handle type tear
IV  (+) Split biceps
V-X (+) Misc injuries

**SLAP 1: Free edge fraying**

**SLAP 2: Avulsion of bicipital - labral complex**

**SLAP 3: Buckethandle sparing biceps anchor**

**SLAP 4: Buckethandle extending into biceps**

**SLAP 5: Bankart extending into biceps anchor**
SLAP 6: Unstable radial or flap tear displacing biceps

SLAP 7: Extending to middle glenohumeral ligament

SLAP 8: Extending to posterior labrum

SLAP 9: SLAP greater than 270 degrees

SLAP 10: Extending into rotator cuff interval

Multidirectional Instability

- Ligamentous laxity
  - MRI:
    - Normal
    - Capsular redundancy (difficult MRI Dx)
- Laxity + labral tear
  - MDI plus injury
  - Combined anterior and posterior traumatic instability
- Arthropathies / glenoid dysplasia
  - Loss/absence of primary stabilizers
Chronic Multidirectional Instability
Combined Anterior and Posterior Instability

- Anterior Dislocation
- Posterior Capsular Ossification
  "Bennett Lesion"

Instability Related to Arthropathies

Amyloid

- e.g., rheumatoid arthritis,
  hemophilia, neuropathic
disease,
prior septic arthritis
- cartilage loss
- labral degeneration / tear
- ossous erosion/cysts
- rotator cuff tear

MDI - Glenoid Dysplasia

- Rare
- Developmentally flat or shallow glenoid with short neck
- absence of primary stabilizer
- chronic instability leads to early OA

Thank You!

William.Morrison@Jefferson.edu  WWW.BONE.TJU.EDU